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from the Author

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ON THE

COAGULATION OF THE BLOOD

AND OTHER

FIBRINIFEROUS LIQUIDS.

BY

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Dr. Buchanan showed some specimens of hydrocelic serum, the fibrin of which was coagulated by means of a few fragments of the *washed clot* of blood added to it sometime before. The coagulated masses were transparent and tremulous, like calf-foot jelly, and so firm as to admit of being inverted on a plane surface without altering their shape. Dr. Buchanan made the following observations in explanation of the phenomenon.

The experiment exhibited to the Society, and the analagous experiments mentioned below seem to me important, as serving to rectify some prevailing opinions as to the essential properties of Fibrin, and the part which it plays in the coagulation of the blood, and certain other physiological processes. They are still farther interesting to me, as enabling me to correct some erroneous views of the constitution of the blood which I entertained, and which having been made public in the first volume of the " Proceedings of the Society," I feel it a duty to rectify.

The opinions commonly entertained by physiologists and chemists, to which allusion has just been made, are, that fibrin has a spontaneous tendency to coagulate: that this spontaneous coagulability is a characteristic property of fibrin, by which it is distinguished from albumen and casein: and that the coagulation of the blood, and of various other animal fluids depends on the spontaneous coagulation of the fibrin which they contain. My experiments, on the other hand, show, that fibrin has not the least tendency to deposit itself spontaneously in the form of a coagulum: that, like albumen and casein, fibrin only coagulates under the influence of suitable reagents: and that the blood, and most other liquids of the body which appear to coagulate spontaneously, only do so, in consequence of their containing at once fibrin and substances capable of re-acting upon it, and so occasioning coagulation.

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* Proceedings of Glasgow Philosophical Society, 19th Feb., 1845.

The liquid of hydrocele, and other dropsical liquids, are generally regarded by physiologists as identical with, or at least closely analagous to the "*liquor sanguinis,*" or liquid part of the blood; which they suppose to be effused, both in health and in disease, from the capillary blood vessels into the serous cavities and cellular interstices of the body. I have elsewhere shown,* that of all these effused liquids that of hydrocele approaches most nearly in its qualities to the serum of healthy blood. In two cases in which the experiment was made, the specific gravity of hydrocelic serum and of the serum of blood drawn from the same individual on the same day, differed very little; and I have recently met with an instance of hydrocelic serum drawn from a very strong man having a specific gravity as high as 1·038, much higher therefore than the ordinary specific gravity of the serum of blood. I entertain no doubt, therefore, that the serum drawn off in cases of hydrocele, is, for the most part, identical with the liquid part of the blood. Such an opinion, however, can scarcely be held by those who believe the liquid part of the blood to be spontaneously coagulable; for, without controversy, the liquid of hydrocele possesses no such property, as I have ascertained by attentive observation in many hundred cases. If carefully drawn off, it may be kept till it putrifies without showing the slightest tendency to coagulate. If, again, as frequently happens, a little blood has been accidentally mingled with it, coagulation may ensue, not spontaneously, but from the re-action of certain elements of the blood upon the dissolved fibrin. This, if we leave out of sight the propensity to make facts bend to theory, is the only explanation that can be given of the assertion frequently made, but so inconsistent with observation, that the fluid of hydrocele is spontaneously coagulable.

What are the elements of the blood that have the power of causing fibrin to coagulate? The washed clot of the blood is the most efficient. It is perhaps indeed the only element of the blood that has the property of coagulating fibrin. The washed clot is the substance which is usually, but very erroneously, named the *fibrin of the blood.* It is best obtained† by mixing one part of liquid blood with from six to ten of water, and stirring them carefully for five minutes, so as to prevent the blood from falling to the bottom and coagulating unmixed. After the mixture has stood from twelve to twenty-four hours, it is to be filtered through a coarse linen cloth, and the product washed with water. The mass thus obtained consists, chiefly, of the insoluble portion of the red corpuscles; next of the colourless granules and globules; and least in quantity of the precipitated fibrin, by which these main constituents of the coagulum are agglutinated together.

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* Med. Gazette, 1836.

† Med. Gazette, 1836.

Let a small quantity of this substance be mixed with the liquid of hydrocele, reducing it to minute shreds, and diffusing it equably through the liquid. Coagulation will ensue in many cases as rapidly as in the liquid blood itself. The coagulum is often quite distinct in from five to ten minutes. It becomes gradually firmer, and in the course of a few hours admits of being passed without breaking from one vessel to another, and very much resembles the transparent tremulous substance of calf-foot jelly. The power which the washed clot has of coagulating fibrin is not less remarkable than that of rennet in coagulating milk, to which, indeed, it may be aptly compared. This experiment is well adapted to the lecture-room—the reagent being added to the liquid serum at the commencement of the lecture, and the coagulated mass shown at the end of it. A very complete illustration of the process by which the blood coagulates may be exhibited by adding to the liquid along with the reagent some pounded charcoal, the particles of which being diffused through the liquid, and getting entangled in the meshes of the nascent fibrin, there is formed a black clot, which, on the addition of a little water, swims in it, just as the blood-coagulum does in the liquid serum.

The washed coagulum retains its coagulating power for a long period—even after its odour indicates the commencement of the process of putrefaction. In preserving it as a reagent, however, I think it advisable to add to it a small quantity of spirits, and to keep it in a stoppered phial. Thus kept, I have found it to retain for several months its power of coagulating fibrin. The serum of hydrocele is the more coagulable the fresher it is. It sometimes soon loses its coagulability on being kept, but more frequently retains it till putrefaction is far advanced. There is, therefore, no difficulty for any one repeating those experiments, and satisfying himself of their truth.

The experiment which I have described is very analogous to some experiments which I performed in the year 1831, and of which I afterwards published an account in the "London Medical Gazette," (April 9, 1836.) I then showed, that if the clot of blood reduced to the liquid state by kneading and expression through a linen cloth, be mixed with hydrocelic serum, the mixture recoagulates into a perfectly homogeneous solid mass, which, like the ordinary coagulum of blood, becomes florid on exposure to the air: and that if a portion of coagulum not so disintegrated be put into a vessel containing hydrocelic serum, a web of fibrin is gradually spun around the coagulum. I showed that these effects were not due to the colouring matter of the clot; but I did not try the effect of the washed clot, my attention having been called in a different direction, by finding that pure serum of blood and hydrocelic serum when mixed together underwent coagulation. On since discovering the efficacy of the washed clot in causing coagulation, I thought it probable that the minute solid particles, which the microscope never fails to detect in the serum of blood, were the agents to which the coagulation of the two kinds of serum when mixed together ought to be ascribed. This corresponded well with the observation which I had long before made, that the deeper the red tint of the blood-serum employed in the experiment, the better does it succeed. On the other hand, Dr. Anderson, in his paper "On the state in which fibrin exists in the blood,"* has shown that if the mixed liquids be carefully filtered, so that no solid particles can any longer be detected by the microscope, coagulation nevertheless ensues; thus rendering it probable that the coagulating principle exists in the serum of blood not as a solid but in a state of solution. It may, however, be objected to this experiment, that the blood-corpuscles pass through any filtering paper, however dense; and that it is impossible by filtration, to deprive turbid serum of the solid particles mechanically diffused through it.

In the summer of last year, after I had satisfied myself as to the power of the washed clot in causing coagulation, I tried the effect of the buffy coat of the blood, reduced to minute shreds, and diffused through the hydrocelic liquid, and found it, in numerous instances, to have a similar power. I even found, that the dried buffy coat from the blood of a horse, which I had kept for several months, on being pulverized and mixed with the liquid, induced coagulation. I found the effect of the colourless buffy coat to be much greater than that of the red clot. I also found the upper part of the red clot to have a stronger coagulating power than the lower part of it. These facts seemed to show that it was the colourless corpuscles of the blood in which the coagulant power was mainly seated. The colourless corpuscles rise to the surface on the blood being drawn, and, there exerting their coagulating power, render the upper part of the clot invariably much firmer than the lower part of it; and this is exactly what is seen in a more marked way, in inflamed blood, in which the colourless corpuscles are much more abundant, and rising by their levity to the surface, form a layer on the top of the red corpuscles; and thereafter, by their superior coagulating power, give rise to the firm crassamentum without redness which we name the buffy coat. As I knew the transparent coagulum, which we find on the surface of newly formed blisters, to consist chiefly of such colourless particles, I tried it as a coagulant, and found it to induce coagulation, although less powerfully than the washed clot of blood. The coagulum, formed artificially in hydrocelic serum by different reagents, seemed to have little coagulating power; as if the transparent granules of fibrin must not only be precipitated, but have acquired more or less of the organized vesicular shape which they have in the blood and in the blister-liquid, before they possess the power of coagulating. This power seemed, therefore, to be the result of organization, and analogous to the metabolic power which Schwann has ascribed to the elementary cellules. This view led me to think it probable, that all the tissues of the body might have a similar power of reacting upon the liquor sanguinis effused into their meshes, and thus contributing to their own development, by engendering there such vesicles as we meet with in the blister-liquid. My first trials made with the muscle and skin of beef well washed to free them of blood, did not succeed; but on trying the muscle of veal, I found it to produce coagulation. I afterwards recognized a similar coagulating power in the muscular substance of beef and veal, in white fish, skin, and cellular membrane: but the effect produced was less remarkable than that of the washed clot, and required a longer time, generally from one to three days. The tissue which answered best was the spinal marrow, probably in part from its greater softness and diffusibility. On one occasion, I found the spinal marrow of a bullock to cause coagulation in half-an-hour, the coagulum formed being very firm and beautiful. The substance of the brain seemed to have less power, although no rigorous comparison of them was made. Last of all, I found that the corpuscles of mucus from the Schneiderian membrane and throat possessed a coagulating power, though tardy: and that even the globules of purulent matter, which are just altered primary cellules, retained their coagulant power; for when put into hydrocelic serum, instead of continuing diffusible through the liquid, they agglutinated themselves together by the intermedium of fibrin, forming a white solid mass, such as we often see of smaller size on inflamed membranes.

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* Proceedings of Glasgow Phil. Soc., vol. i. p. 201.

These various experiments fully satisfied me that the tissues possess the property of coagulating fibrin: and I was farther disposed to think, that this power was most energetic in the primary cells or vesicles; and less energetic as these cells passed into secondary forms, as in the red corpuscles of the blood, the pus globules, and the various tissues of the body. This corresponds well with the greater vigour of development in fœtal life and infancy, when the tissues have deviated little from their primary structure; and the gradual diminution of the activity of the function as life advances, and the tissues are more and more altered. The coagulation of the fibrin of the effused liquor sanguinis, under the influence of the primary cells and tissues, may probably, therefore, be regarded as the primary organizative act by which the assimilable matter dissolved in the nutritious liquid passes into the form of an organized solid.

It is scarcely necessary for me to add, that I am now satisfied, that the fibrin of the animal fluids exists in them in solution, previous to its appearing in a corpuscular form: and that the liquor sanguinis differs from the serum which separates from the blood-coagulum in this respect, that the former contains fibrin in solution, while the latter has been *defibrinized* by the action of the colourless blood-corpuscles upon it. I also think the theory of the production of cell-germs and cells by the reaction of the two kinds of serum upon each other, less probable than the theory of their formation stated above. The same theory may also be applied to explain the origin of the blood-corpuscles in the capillary lymphatics, and the production of the numerous less regular corpuscles which are formed in the capillary blood-vessels during inflammation, and which, after mingling with the circulating blood, rise to its surface when drawn, and reacting on the fibrin occasion the buffy coat of the blood. The opinion expressed by Dr. Anderson in his paper already quoted, that the blister-liquid contains fibrin which is precipitated during coagulation, I believe to be correct in many cases, as I have sometimes found that liquid, when acted upon by the washed clot, to deposit fibrin: in other cases again, I have found, on applying the same test to the blister-liquid, that it contained little or no fibrin; and in such cases, I believe the coagulum which forms in it, to result from the simple aggregation of the organized corpuscles which it contains, as observation with the microscope first suggested to me.

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